RFID Alliance Lab: Deploying Gen 2
May 2, 2006

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Who We Are

- Evaluate RFID products in a *scientific* way
- Provide useful, timely, credible, and unbiased data to end users of RFID products
- Constituents
  - **University of Kansas / ITTC**: Primary research contributor
  - **RFID Journal**: Initial funding, distributor, advertisement
  - **Rush Tracking Systems**: Initiator, industry lesion
- Business model
  - Sell reports (~$1,000 / report) to finance future reports
  - Sponsorships
  - Research projects
- ITTC/KU Applied Research Labs
- Helping companies solve hard problems
  - Tagging small electronics devices
  - Seknion: direction of travel through portal
  - Tagging metal assets
- Adamas: high performance low profile metal tag
- Basic research
  - RFID privacy using CDMA

- We would like to talk with you about your hard problems

Outline

- What factors affect RFID tag performance?
- Are all readers basically the same?

Tagging Products: A Brief How-To

- Gen 2 tag performance depends on the antenna and its environment

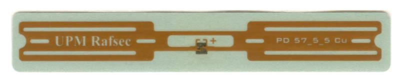
1. Aperture
   - How “big” is the antenna?
2. Antenna Efficiency
   - How well is it living up to its potential?
3. Dielectric Loss
   - How much power is being lost to the environment?
4. Power Transfer
   - Is the power delivered to the RFID chip?
5. Chip efficiency
   - How little power needs to get to the RFID chip?

1. Aperture
Size Matters

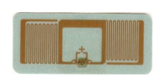
- 6.1” tag
  - 4× power of 3.75” tag
  - ≈ 2× distance
  - Does not fit on 6” label
- 3.75” tag
  - ≈ ½ distance of 6.1” tag
  - ≈10× power of item tag
  - Convenient form factor
- 1.2” tag
  - Short ~5 ft read distance
  - Highly orientation-dependent

- 6.1” Symbol tag

- 3.75” Raflatec tag



- 1.2” Raflatec item tag



2. Antenna Efficiency Tuning Matters

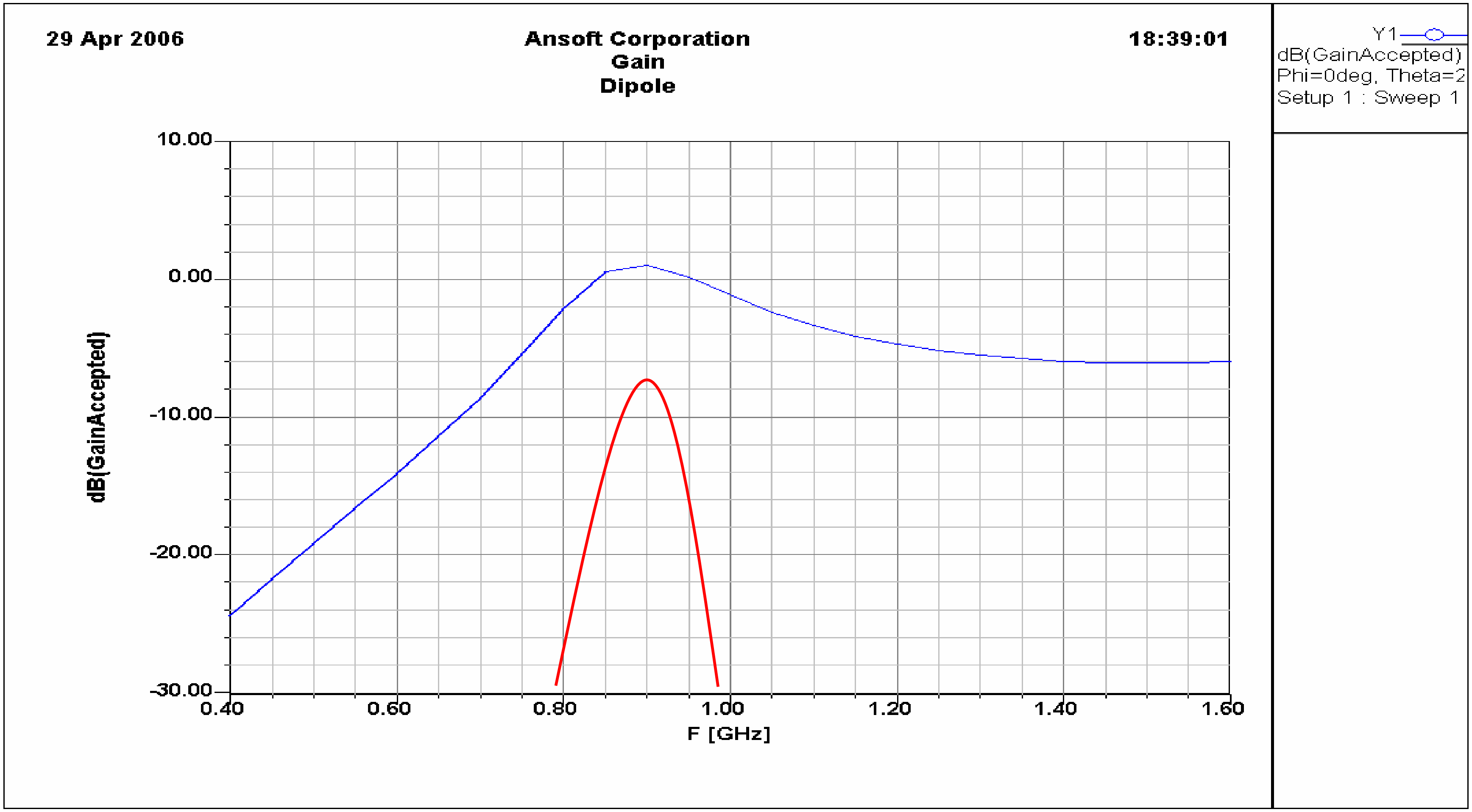
- A tuning fork "resonates" well at a one frequency (plus harmonics)
- "Serpentine" dipoles meander so electrical length longer than physical length
- The speed (velocity) of light (or RF) is not a constant!

$$v = \frac{c}{\sqrt{\varepsilon_r}}$$

- Near-by materials affect tuning

Material	Dielectric Constant	Resonant Frequency (MHz)
Air	1.0	915
Plastic (Polyethylene)	2.25	768
Plastic (PVC)	3.4	676
Glass	5.5	570
Water	80	180

Metal Increases "Q," Decreases Bandwidth



3. Dielectric Loss
Materials Can Absorb Power

- In optics: transparent, reflective, flat black
- RF fields develop around tag antenna
- Fields passing through opaque materials lose power to those materials
  - E.g., aerodynamic drag, or boat anchor
- The closer to the antenna, the worse the affects
- Water worst offender; liquids tend to be bad
- Not affect with metal

4. Power Transfer Between Antenna and Chip

- Sun reflecting off the water
  - Some goes into the water
  - Some gets reflected
- Power transfer between antenna and chip is critical
- $$S_{11} = \frac{Z_L - Z_S}{Z_S + Z_L}$$

Swift Current Lake
Glacier National Park

More on Power Transfer Efficiency

Power transfer efficiency is affected by

- Frequency, and therefore dielectric constant of close materials
  - Antenna impedance peaks at resonance
  - Phase positive below, negative above resonance
- Dielectric loss of close materials
  - Higher loss tends to decrease Z_S overall
- Metal close to tag
  - Metal can *drastically* increase Z_S especially at resonance

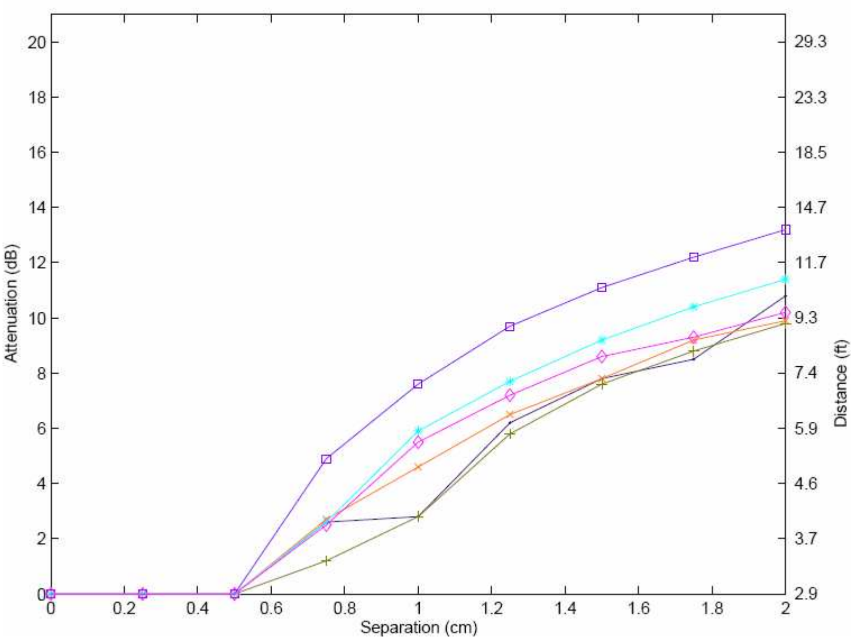
5. Chip Efficiency

- Chip performance depends on
  - Power consumed
  - Power reflected
- In the end, you get what you can get
- Impinj currently dominates the market
- **Many** new market entries this year and beyond

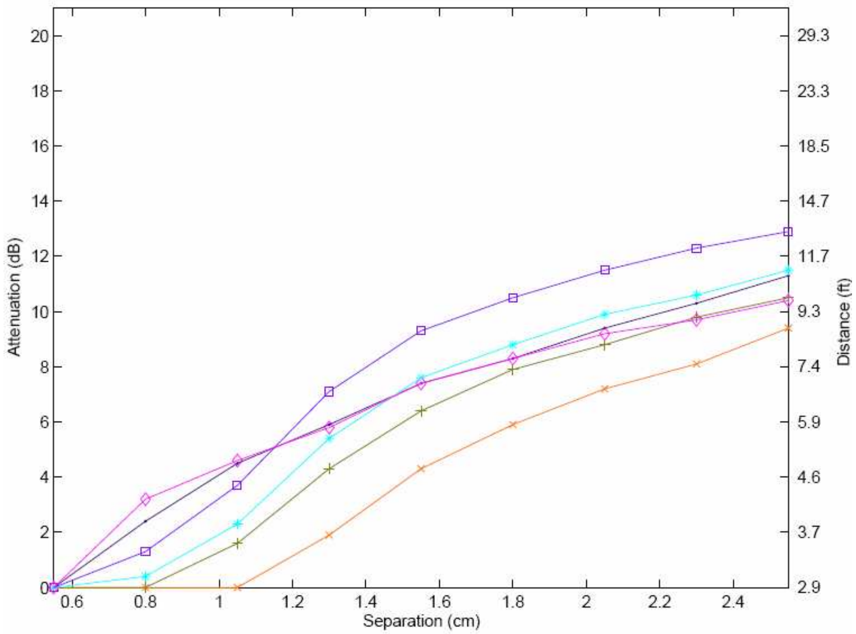
Materials Impact Tag Performance: Appoximate

	Plastics	Ceramic	Metal	Water
Aperture				
Antenna Efficiency	◆	◆ ◆		◆ ◆ ◆ ◆
Dielectric Loss	◆	◆ ◆		◆ ◆ ◆ ◆
Power Transfer	◆	◆ ◆	◆ ◆ ◆ ◆	◆ ◆ ◆
Chip Efficiency				

Experimental Data: Tag Performance vs. Separation

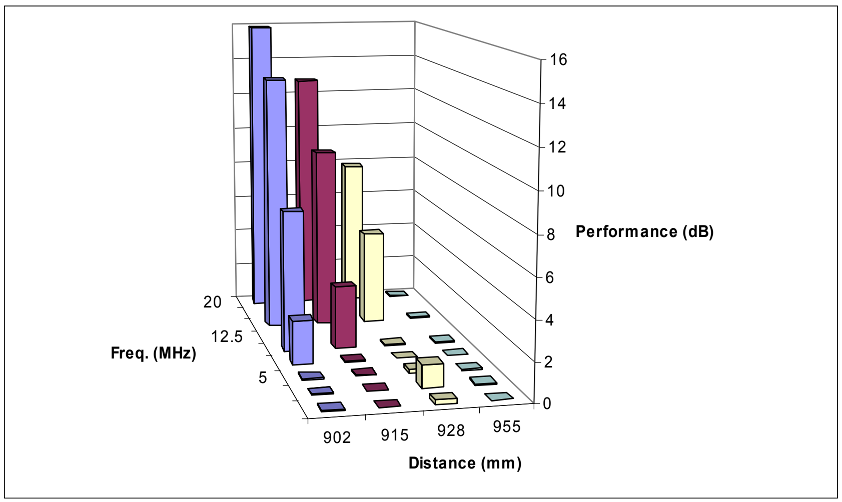


Separation from Metal

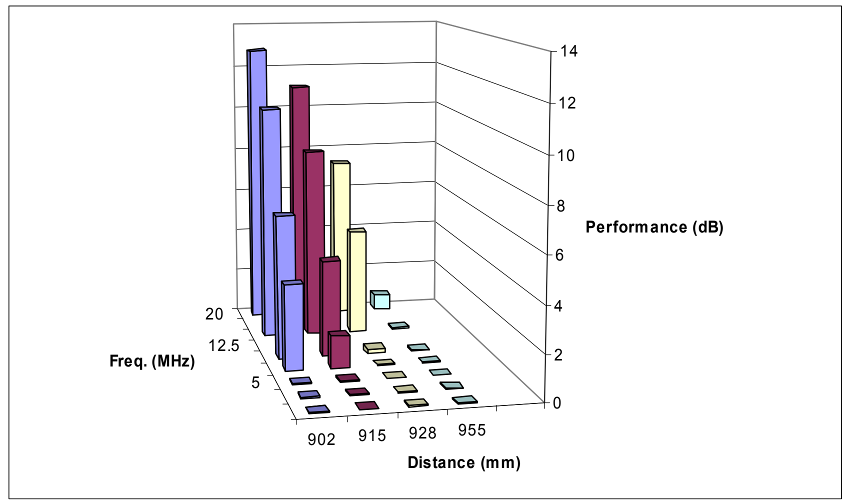


Separation from Water

Experimental Data: Tag Performance vs. Separation



Separation from Metal



Separation from Water

What To Do?

- Stay away from metal and water
  - Place antenna in natural air gaps
  - Create air gaps
- Use spacers
  - Foam best: mostly air
  - Plastic poor
    - Makes narrowband
    - Changes resonant frequency
- Use specialty tags

Metal Tag Market Solutions

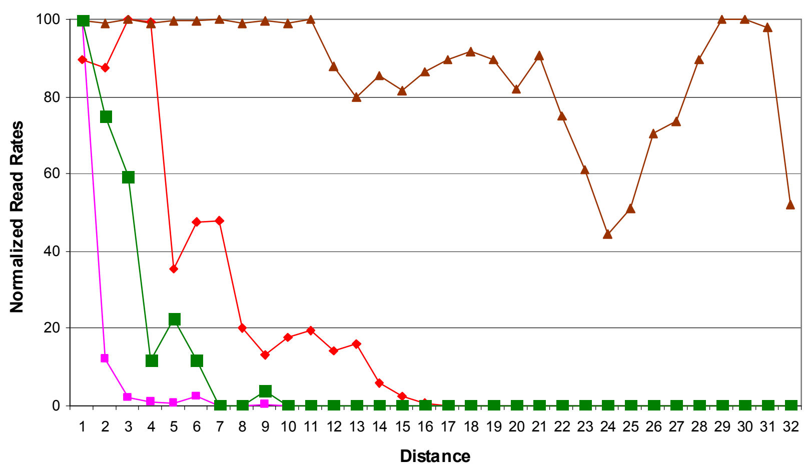
- Sticks
  - Dipoles with high dielectric material
  - Thick dipoles
- Stand-offs
  - Foam – absorbs moisture
  - Plastic – changes resonance
- Isolators
  - Change resonant frequency to ≈300 MHz
  - Add enough loss to counter affects of metal
  - Thin: some around 0.05” or 1.2 mm
  - Modest performance

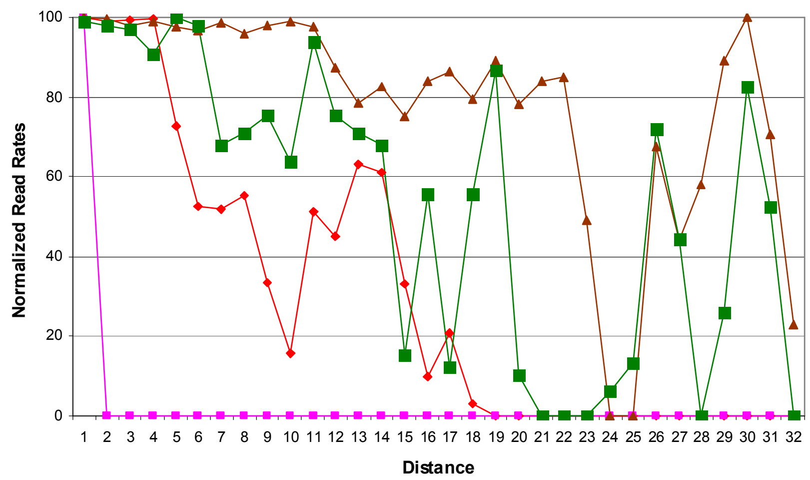
Adamas-I Tag

- Thin microstrip “patch” antenna
  - 0.06” or 1.6mm
- Dual balanced feed
- Inexpensive materials
  - Polyethylene, Polypro
- Completely planar design
  - Via-free
- High performance
  - 30 ft+ reads on metal, water
- Bandwidth limitations being addressed
  - 26 MHz BW with > -4dBi
- See us at booth #117

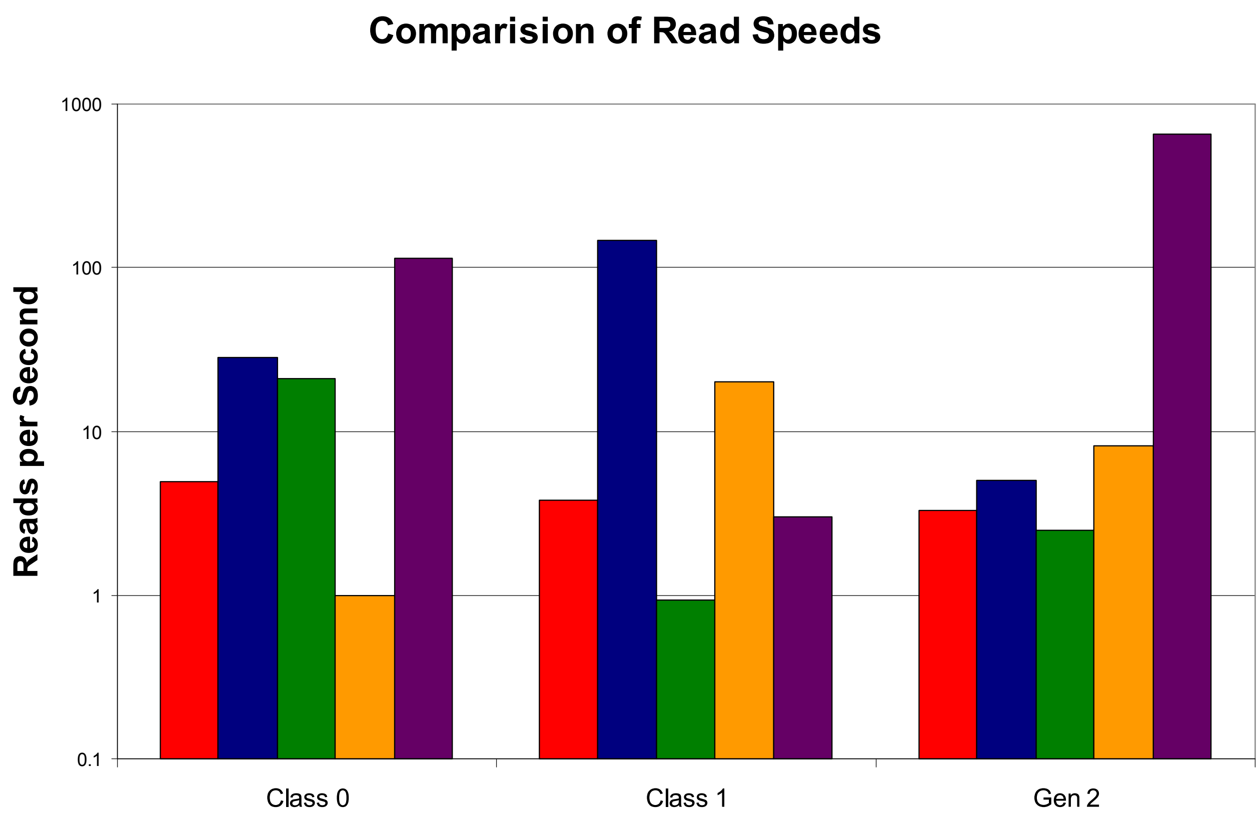
Not All Readers are Alike

- Two Gen 2 tags
- Four Gen 2 certified interrogators
- Even different relative performance





Speeds with Multi-Protocol Readers



Conclusions

- For tag antennas, size matters
- Keep tags away from water, metal
  - Use a specialty tag for asset tracking
- Wide performance differences in readers
  - Read distances
  - Read speeds
  - Features